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Pedogenic Assessment of Hydromorphic Soils in Two Inland Valley Swamps in Ogbomoso and Ondo, Southwestern Nigeria

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Abstract
This study investigated the physical, chemical and morphological properties of hydromorphic soils in two inland valley swamps and evaluated their suitability for crop production in Ogbomoso and Ondo, Southwestern Nigeria. The study was conducted at two Teaching and Research Farms of two Universities: Ladoke Akintola University of Technology, Ogbomoso and Wesley University, Ondo. Two pits were dug at each site and soil samples were collected from each profile pit at all the identified genetic horizons. Prepared composite soil samples were subjected to laboratory analysis for the determination of selected physical and chemical characteristics following standard procedures. Data generated were subjected to descriptive statistics, including range, mean, standard deviation and coefficient of variation. The study showed that Ogbomoso soils were deep (> 100 cm depth) and the soil colour ranged from brownish grey (5 YR 5/1) to light greyish (5 Y 6/2) at the top soil. The texture of the top soil varied from loamy sand to sandy loam. The silt/clay ratios ranged from 0.5 to 4.0 with mean value of 1.30. The soil pH was generally acidic with mean values of 5.32. Three of the basic cations (potassium, sodium, calcium) were generally low with mean values of 0.18, 0.10 and 0.77 cmolkg^{-1} respectively while magnesium was high (1.43 cmolkg^{-1}). Mean values of organic matter (0.92 %), total nitrogen (0.09 gkg^{-1}) and phosphorus (1.60 mgkg^{-1}) contents were low. Extractable iron (0.76 mgkg^{-1}), zinc (2.64 mgkg^{-1}) and copper (3.48mgkg^{-1}) values were very low while manganese (47.71 mgkg^{-1}) was high. Ondo soils characteristics showed similar trend with Ogbomoso soils. The soils were deep (> 120 cm depth), with light grey (5Y 8/2) colour at the top soil. The textures were predominantly loamy sand, the silt / clay ranged from 0.5 to 1.7 with mean values of 1.06 indicating weakly developed soils with young parent materials. The soil pH was generally acidic with mean values of 4.26. Potassium, Sodium, Calcium were generally low with mean values of 0.19, 0.06 and 0.73 cmolkg^{-1} respectively while magnesium was high (1.67cmolkg^{-1}). Organic matter (0.77 %), total nitrogen (0.31 gkg^{-1}) and phosphorus (1.61 mgkg^{-1}) contents were low. Iron (1.90 mgkg^{-1}), zinc (2.26mgkg^{-1}) and copper (2.01mgkg^{-1}) were very low while manganese (19.43 mg kg^{-1}) was high. It was concluded that the soils at the two locations were not fully developed and young (Entisols). The low macro and micronutrients in the soils at the two sites indicated need for incorporation of organic and inorganic fertilizers into the soils for optimum crop production.

Keywords: Hydromorphic, Micronutrient, Entisol, Extractable iron.

Introduction
Soil is roughly consisted of 50 % solids, 25% water and 25 % air, the basic composition of soil air consists of nitrogen (78 %), oxygen (18-20 %), carbon dioxide (1-10 %), vaporized water (concentration is temperature dependent) and trace gases. However, soil air can be replaced by water when soil is permanently or temporarily waterlogged and if the saturation period is long enough to eliminate the oxygen from the soil thereby causing reducing conditions in that soil.

This state of permanent or temporary water saturation in the soil associated with conditions of reduction is considered as hydromorphism and this state has considerable effects in the composition, properties, genesis and evolution of the soil (Jacob and Otte, 2003). Hydromorphic soils fall under Gleysols in the system World Reference Base for Soil Resources, (2006) (WRB) which correlates are synonymous to *Aqualfs*, *Aquents*, *Aquepts*, *Aquolls*, etc on US Soil Taxonomy.

In Southwestern Nigeria, the inland valleys cover about 100,000 ha in the humid and another 100,000 ha in the Savannah area (Ogban and Babalola, 2009). The need to understand the importance of soil nutrients is highly overbearing for improved productivity of both the soil and crops (Mustaza *et al.*, 2011). As population of the world

continues to increase and the problems of producing adequate nutritious food for this growing population is becoming apparent, thus calling for cultivation of hydromorphics soils in inland valley. Dar (2004) stated that there is need to monitor soil micronutrients status through analysis of soils in farmer's field. There is an urgent need to ensure that each farmer knows the productivity capability of the soil in order to ensure viable and sustainable agriculture. In view of these, this study was undertaken to assess the physical and chemical properties of the soils in two inland valleys in Ogbomoso and Ondo towns, Southwestern Nigeria, in order to provide baseline information to the users of the land and to predict /suggest the management strategies that could be adopted for the soils and soils with similar characteristics.

Materials and Methods

Study Area

Two inland valley swamps were studied, one in Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso, Oyo State, Nigeria, a savanna region and Wesley University Teaching and Research Farm, Ondo, Ondo State Nigeria representing forest zone. The Ogbomoso site was characterized by concave contours with a lower concave slope. Its coordinates are approximately latitude 08º 95' N and longitude 04º 25' E located in Southwestern, Nigeria. The climate is tropical, notably with dry and wet seasons with relatively high humidity. Average daily temperature ranges between 25 °C and 35 °C, almost throughout the year, the mean annual rainfall is 1400mm in bimodal pattern of distribution reaching peaks around July and September. The area has been under cultivation for more than ten years; presently the land is under a mixture of bush re-growth and arable crops. The Ondo site is situated at latitude 07° 1' N and longitude 04° 83' E. The climate of Ondo is of the lowland tropical rain forest type, the mean monthly temperature and its range are 30^0 C and 32^0 C respectively.

Field Studies

Two profiles were excavated dug at each site at about 100 m distance apart. The profiles were described according to recommended procedure of the Food and Agriculture Organization (1977) and Soil Survey Staff (2003). Samples were taken from each horizon and sealed in well labelled nylon bags. The soil samples were air dried, crushed with mortal and pestle and sieved with 2mm sieve to separate gravel (>2 mm). The fine proportion (<2mm) was used for laboratory analyses.

Laboratory Analyses

Air – dried soil samples were subjected to physical analysis: particle size analysis was determined using hydrometer method (Bouyoucos, 1962) as modified by Gee and Or (2002) and the textural classes were determined using a textural triangle. Soil pH was determined in distilled water using pH meter after equilibration for 30 minutes. The soil samples were also subjected to chemical analyses. Exchangeable bases (Ca, Mg, Na and K) were extracted with neutral 1.0 M NH_4OAc solution. Calcium and Mg in the extract were analysed by atomic absorption spectrophotometry while Na and K were determined with a flame photometer. The exchangeable acidity (H^++Al^{3+}) in the soil was extracted with 1M KCl (Thomas, 1982). Solution of the extract was titrated with 0.05M NaOH to a permanent pink endpoint using phenolphthalein as indicator. The amount of base (NaOH) used is equivalent to the total amount of exchangeable acidity (H^++Al^{3+}) in the aliquot.

The summation of exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) and total exchangeable acidity (H^++Al^{3+}) gave the effective cation exchangeable capacity (ECEC) (Juo *et al.,* 1974). Percentage base saturation was calculated as the ratio between the sum of exchangeable bases and effective cation exchangeable capacity multiplied by 100. The micronutrients (Zn, Mn, Fe and Cu) were extracted with 0.1M HCl (Juo *et al.,* 1974) and their concentrations in soil extracts were analysed by atomic absorption spectrophotometry after extraction with neutral 1.0 M NH4OAc. Organic carbons were determined by Walkley – Black method (1934).

Total nitrogen in the soil samples were determined by Macro – Kjedahl method (Bremmer, 1996) using ortho – phosphoric plus sulphuric acid mixture for digestion at 370 °C for 3 hours in Tecator digestor system (IITA, 1982), with N estimated by Technicon's (AAII) auto – analyser. Available P was extracted by the Mehlich III – extraction, (Mehlich, 1984). A 2.5 g sample of air-dried soil were put in a 50 ml centrifuge tube. To each tube, 25 ml of Mehlich III extracting solution were added (soil: water solution ratio 1:2). Each tube was filtered into plastic vials using medium retention filter paper (Whatman No. 40). The solution was used for subsequent P determination using colorimetric method.

Statistical Analysis

The statistical tool adopted for analysing the data obtained were range, mean, standard deviation and coefficient of variation.

Result and Discussion

Morphological features

The morphological properties of the soils studied is shown in Table 1. The studies showed that the soils were deep (> 100 cm) and sandy. The soils were greyed up at the soil surface. This indicates that hydromorphism is a common trait of the inland valley swamp, showing strong influence of soil water saturation during raining season. The same observation was reported by Egbuchua and Ojeifo (2007). The textures were loamy sands all through except for Pedon OGB 2 which was sandy loam at the surface. The rather sandy nature of the soils gave rise to weak, structureless and sub-angular blocky structure. The consistence varied from non-sticky, slightly sticky, very sticky, and sticky. Many fine tubular pores, few roots, gradual wavy, clear smooth and gradual boundaries were major morphological evidence of the soils at the two locations. The soils were imperfectly drained, an important characteristic of wetland soils.

Table 1: Morphological characteristic of the soils of the inland valleys

Horizon	Depth (cm)	Matrix	Mottle	texture	structure	consistence	Boundary
Pedon OGB- Pt 1							
	0 – 28	5YR5/1	5Y6/2	Loamy Sand	0, sbk	Ns	Gw
	28 – 47	5Y7/1	5Y8/2	Loamy Sand	1, sbk	Ss	Gw
	47 – 74	2.5Y8/6	5Y8/3	Loamy Sand	1, sbk	Ss	Ds
	74 – 109	10YR7/8	2.5Y7/6	Loamy Sand	1, sbk	Vs	Aw
	109 – 120	10YR8/8	5Y8/6	Loamy Sand	1, sbk	Vs	G
Pedon OGB – Pt 2							
	0 – 16	5Y6/2	2.5Y6/3	Sandy Loam	0, sbk	Ns	Cs
	16 – 44	2.5Y7/1	2.5Y7/2	Loamy Sand	1, sbk	Ss	Cs
	44 – 137	2.5Y7/4	2.5Y6/3	Loamy Sand	1, sbk	Vs	
Pedon OND – Pt 1							
	0 – 38	5Y8/2	5Y8/2	Loamy Sand	0, sbk	Ns	Gw
	38 – 85	5Y8/1	5Y7/8	Loamy Sand	1, sbk	Ss	Gw
	85 – 124	2.5Y7/8	2.5Y7/6	Loamy Sand	1, sbk	Vs	G
Pedon OND – Pt 2							
	0 – 23	10YR7/1	2.5Y6/2	Loamy Sand	0, sbk	Ns	Cw
	23 – 52	2.5Y8/2	2.5Y8/1	Loamy Sand	0, sbk	S	Cb
	52 – 87	5Y7/4	5Y8/3	Loamy Sand	1, sbk	S	Cw
	87 – 102	5Y7/6	5Y6/8	Loamy Sand	1, sbk	S	Cw
	102 – 130	5Y7/3	2.5Y7/3	Loamy Sand	1, sbk	Vs	G

Abbreviations

1. Structure : 0 = structureless, 1 = weak, sbk = subangular blocky.
2. Consistence : Ns – Non Sticky, Ss – Slightly Sticky,Vs – Very Sticky, S - Sticky
3. Boundary : Gw – Gradual Wavy, G – Gradual, Cw – Clear Wavy, Cb – Clear broken, Cs – Clear Smooth, Ds – Diffuse Smooth, Aw – Abrupt Wavy
4. OGB-Pt : profile pit located in Ogbomoso, OND- Pt: profile pit located in Ondo

Physical Characteristics

Table 2 shows the selected physical properties of the soils at the study sites, while the range, mean, standard deviation and coefficient of variance for inland valley soils at Ogbomoso and Ondo are shown in Tables 3 and 4 respectively. Sand fraction was the most dominant particles in the soils at the two locations. The sand fractions were erratically distributed within the profiles, with mean values of 80.9 and 84.2 % for soils at Ogbomoso and Ondo sites respectively. Sand dominance was attributed to surface wash of medium to fine particles from the crest slope position and moved down the slope for the two sites, the activities of water and clay eluviations might have caused the decrease in sand fractions with increasing soil depth. The silt mean values were 10.3 and 8.0 % for Ogbomoso and Ondo sites respectively.

The clay contents were low in the surface horizons but increased gradually in the subsoil horizons with no definite pattern of distribution. In all the soils at the study sites, the clay contents were higher at the B horizon thus confirming the presence of argillic horizon. Ojanuga *et al.,* (2003) also reported that low clay content of surface soils was due to lessivation of soil materials by biological activities. Irregular distribution of sand and clay in the profile

horizons suggested different periods of deposition of sediments rather than, the deep weathered nature of the parent materials in-situ. The high amount of clay particles in the subsoil will implied temporary stagnation of water at B-horizon. The common rooting zone of most arable crops is within 50cm, root of crops are normally located within this region of the soil which could be termed as water lodged or saturation depth, which in turn will affect the nutrient uptake, aeration and root growth. Silt fractions were also irregularly distributed; the same observations have been observed and reported by Ojanuga *et al.,* (2003) which proved that the soils were weakly developed.

Table 2: Selected physical properties of the soils of the inland valley studied

Horizon Clay	Depth (cm)	Sand	Silt	Clay	Textural Class	Silt: Clay
Pedon OGB- Pt 1						
	0 – 28	86.4	6.8	6.8	Loamy Sand	1.0
	28 – 47	87.2	7.2	5.6	Loamy Sand	1.3
	47 – 74	86.0	7.2	6.8	Loamy Sand	1.1
	74 – 109	75.2	11.2	13.6	Loamy Sand	0.8
	109 – 120	78.0	8.8	13.2	Loamy Sand	0.7
Pedon OGB – Pt 2						
	0 – 16	66.0	27.2	6.8	Sandy Loam	4.0
	16 – 44	86.4	4.8	8.8	Loamy Sand	0.5
	44 – 137	82.0	9.2	8.8	Loamy Sand	1.0
Pedon OND – Pt 1						
	0 – 38	86.0	7.2	6.8	Loamy Sand	1.1
	38 – 85	84.0	5.2	8.8	Loamy Sand	0.5
	85 – 124	82.4	8.8	10.8	Loamy Sand	0.8
Pedon OND – Pt 2						
	0 – 23	84.0	8.8	5.2	Loamy Sand	1.7
	23 – 52	84.0	8.8	7.2	Loamy Sand	1.2
	52 – 87	88.0	6.8	7.2	Loamy Sand	0.9
	87 – 102	81.2	11.2	7.6	Loamy Sand	1.5
	102 – 130	84.0	7.2	8.8	Loamy Sand	0.8

OGB-Pt : profile pit located in Ogbomoso, OND- Pt: profile pit located in Ondo

The silt / clay ratios ranged from 0.5 – 1.7 with mean values of 0.5 – 1.3 for the two locations. According to Wilson, (2010), silt / clay ratios of any given soil that is below 0.15 is an indication that the soil is of old parent materials, while those above 0.15 shows that the soil is of young parent materials with low degree of weathering. This implies that the study areas were young soils with different degree of weathering. Ogbomoso study site however had lower degree of weathering compared to Ondo study site. The coarse texture of surface soil for Ondo is suggesting low water holding capacity.

Table 3: Range, mean (x), standard deviation (sd) and coefficient of variance (cv %) for some selected physical properties of inland valley swamp soils at Ogbomoso study site.

Variables	Range	Mean (X)	SD	CV %
Sand	66.0 – 87.3	80.90	6.98	8.63
Silt	4.8 – 27.2	10.30	2.25	21.84
Clay	5.6 – 13.6	8.80	1.00	11.42
Silt: Clay	0.5 – 1.7	1.30	0.13	10.06

Table 4: Range, mean (X), standard deviation (SD) and coefficient of variance (CV %) for some selected physical properties of Ondo inland valley swamp soils at Ondo study site

Variables	Range	Mean (X)	SD	CV %
Sand	81.2 – 88.0	84.2	1.94	2.30
Silt	5.2 – 11.2	8.00	1.64	21.13
Clay	5.2 – 10.8	7.8	1.56	20.03
Silt: Clay	0.5 – 1.3	1.06	0.37	34.96

Chemical Characteristics

The result of chemical properties of the soil studied is shown in Table 5, while the range, mean, standard deviation and coefficient of variation are shown in Tables 6 and 7 for Ogbomoso and Ondo study sites respectively. The Soil pH were generally acidic with the range of 3.67 - 5.65 and mean values of 5.32 and 4.26 for Ogbomosho and Ondo study sites respectively. Soil pH was observed to increase or decrease irregularly with increasing depth. The acidic nature of the soils could be attributed to the acidic nature of parent rocks and leaching effects. The effects of moderate rainfall and low cropping intensity can also influence the acidic nature of the two study sites (Oyekunle *et al.,* 2011).

According to Esu (1991), magnesium was rated low at < 0.3 $cmolkg^{-1}$, medium at 0.3 to 1.0 $cmolkg^{-1}$ and high at> 1.0 $cmolkg^{-1}$, exchangeable potassium was rated low at < 0.15 $cmolkg^{-1}$, medium at 0.15 to 0.3 $cmolkg^{-1}$, and high at> 0.3 $cmolkg^{-1}$. Based on this rating, K, Na, and Ca were generally low with respective mean values of 0.18 and 0.19 $cmolkg^{-1}$, 0.10 and 0.06 $cmolkg^{-1}$, 0.77 and 0.73 $cmolkg^{-1}$ for Ogbomoso and Ondo study sites respectively. Magnesium was however, high at both study sites with the mean value of 1.43 and 1.67 $cmolkg^{-1}$ respectively. The low levels of exchangeable cations in the soils might be attributed to the acidic condition of the soil, crop removal, soil texture and parent materials from which the soils were formed.

The organic matter contents were generally low across the soil units with mean values of 0.92 and 0.77 % respectively for Ogbomoso and Ondo study sites. Bownan *et al.*, 1990 attributed the low organic carbon content to continuous cultivation without fallow, bush burning, high rate of mineralization due to high temperature. The decrease in content down the profile indicates maturity in the profile.

Total nitrogen contents were also low for the two locations. The mean values were 0.09 and 0.31 % for soils at the Ogbomoso and Ondo study sites respectively. These values were far below 1.5 - 2.0 % established as critical value range for most Nigeria soils (Ewetola *et al.*, 2015). The low total nitrogen contents of the soils could be as a result of leaching coupled with intermittent flooding and drying which is known to favour NH_3 volatilization and denitrification which is common in wetland soils (Oyekunle et al., 2011). The available phosphorus was low across the soil units with mean values of 1.60 and 1.61 $mgkg^{-1}$for Ogbomoso and Ondo inland valley studied sites respectively. These low values could be associated with high contents of siliceous parent materials, high phosphorus adsorption capacity and the acidic nature of the soils.

The generally low Organic matter, total nitrogen and available phosphorus contents of these soils may be due to low vegetation cover in the area along with low clay activities (Ewetola *eta al.*, 2015). The CEC mean values were 2.84 and 3.56 $cmolkg^{-1}$ for Ondo and Ogbomoso respectively. According to Esu (1991) soils with CEC< 6.0cmolkg were low, 6-12 were medium and > 12.0$cmolkg^{-1}$ were high, and according to this classification, soils of the studied area were generally low in CEC. The low CEC values buttress the low clay and organic matter contents. The soils of the study area were generally low in iron content. The mean values for extractable iron content were 0.76 and 1.90 $mgkg^{-1}$ for Ogbomoso and Ondo study sites respectively. Vepraskas (2001) reported low Fe in a sandy soil that was due to low Fe content in the parent material. The mean total manganese values of the soils of the studied area were 47.71$mgkg^{-1}$ for Ogbomoso soil, and 19.43$mgkg^{-1}$ for Ondo soils. Total Mn were irregularly distributed within the profile suggesting that it was not tied to any single soil property or a particular pedogenic process. The high Manganese content of the soils of the study area may be due to high content of Manganese in the parent materials from which the soils were formed. Total zinc content of the study area were 2.64$mgkg^{-1}$ for Ogbomoso soils, and 2.26$mgkg^{-1}$ for Ondo soils respectively. The soils of the studied areas were high in Zinc. Copper contents of the Ogbomoso and Ondo soils were 3.48 and 2.01 $mgkg^{-1}$ respectively. Godwin and Omolola (2012) reported ranges of 1.6 -14 $mgkg^{-1}$ for soils of South Western Nigeria. Ogbomoso inland valley soils had higher copper contents than Ondo inland valley soils. The value for Aluminium saturation was low in both studied sites suggesting that there was no problem of aluminium toxicity. Aluminium content decreased significantly with increased soil depth. It has a mean value of 1.02 $Cmokg^{-1}$ for Ogbomoso and 1.18$Cmokg^{-1}$ for Ondo inland valley soils.

Table 5: Selected chemical properties of the soils of the inland valley studied

Horizon	Depth (cm)	pH	Exchangeable Cations (cmolc kg^{-1})						
			K	Na	Ca	Mg	H^+	Al	CEC
Pedon OGB 1									
AP	0 – 28	5.65	0.31	0.24	2.00	1.03	0.13	1.52	3.71
AB	28 – 47	5.52	0.15	0.06	2.00	0.34	0.13	1.04	2.68
B1	47 – 74	5.55	0.17	0.06	0.80	0.50	0.13	1.48	1.66
B2	74 – 109	4.80	0.18	0.10	0.57	0.57	0.57	0.10	2.99
C	109 – 120	4.83	0.17	0.08	2.00	1.14	0.63	0.86	4.02
Pedon OGB 2									
AP	0 – 16	5.43	0.16	0.08	1.14	0.50	0.14	1.17	2.02
B	16 – 44	5.32	0.16	0.07	2.51	0.46	0.14	1.12	3.34
BC	44 – 137	5.44	0.15	0.08	1.34	0.68	0.14	0.87	2.31
Pedon OND 1									
AP	0 – 38	4.02	0.18	0.06	1.84	1.03	1.00	1.43	4.11
B	38 – 85	4.39	0.20	0.06	2.00	0.80	0.83	1.26	3.89
BC	85 – 132	4.45	0.14	0.03	1.34	0.80	0.81	1.14	3.12
Pedon OND 2									
AP	0 – 23	3.67	0.24	0.10	2.84	1.14	1.17	1.28	5.49
AB	23 – 52	4.24	0.14	0.06	1.34	0.34	0.90	1.10	2.78
B1	52 – 87	4.69	0.16	0.05	1.34	0.68	0.69	1.11	2.92
B2	87 – 102	4.13	0.16	0.06	1.50	0.34	0.95	1.07	3.01
C1	102 – 106	4.22	0.27	0.09	1.17	0.68	0.91	1.03	3.12

OGB-Pt: Profile pit located in Ogbomoso, OND- Pt: profile pit located in Ondo

Table 6: Distribution of Macronutrient, Available Phosphorus, Organic Carbon and Nitrogen content in the soil profiles of the study site

Horizon	Depth (cm)	Av.P ($mgkg^{-1}$)	OC %	N	Fe	Cu $mgkg^{-1}$	Zn	Mn
Pedon OGB 1								
	0 – 28	2.57	1.12	0.07	0.73	0.73	3.2	103
	28 – 47	1.14	0.86	0.08	0.62	2.5	1.8	32.7
	47 – 74	1.67	0.82	0.08	0.63	4.2	1.1	19.8
	74 – 109	1.67	0.8	0.09	0.56	3.5	5.2	8.2
	109 – 120	1.47	0.74	0.01	1.11	4.6	3.5	12
Pedon OGB 2								
	0 – 16	2.04	1.18	0.12	0.87	3.1	1.9	92.5
	16 – 44	0.53	1.15	0.12	0.8	2.4	1.3	49
	44 – 137	1.72	0.71	0.07	0.75	4.7	3.1	64.5
Pedon OND 1								
	0 – 38	1.43	0.85	0.06	2.97	2.1	2.8	23.7
	38 – 85	3.12	0.56	0.84	2.04	0.85	2.4	1.5
	85 – 132	1.84	0.09	0.09	1.44	2.4	1.5	8.3
Pedon OND 2								
	0 – 23	1.51	1.47	0.15	2.18	2	3.4	58
	23 – 52	0.33	1.08	0.09	1.74	2.2	2	30.3
	52 – 87	0.98	0.35	0.04	1.64	2.8	2	13.7
	87 – 102	1.8	0.88	0.11	1.92	2.1	2.7	12.4
	102 -106	1.88	0.88	0.09	1.46	1.7	1.3	7.5

OGB-Pt: profile pit located in Ogbomoso, OND- Pt: profile pit located in Ondo

Table 7: Range, Mean (X), Standard deviation (SD) and coefficient of variance (CV %) of chemical properties of Ogbomoso inland valley swamp

Variables	Range	Mean	SD	CV %
pH	4.80 – 5.65	5.32	0.32	5.64
K^+ ($cmolkg^{-1}$)	0.15 – 0.31	0.18	0.05	27.8
Na^+ ($cmolkg^{-1}$)	0.06 – 0.24	0.10	0.06	60.0
Ca^{2+} ($cmolkg^{-1}$)	0.34 – 1.14	0.77	0.29	37.7
Mg^{2+} ($cmolkg^{-1}$)	0.50 – 2.51	1.43	0.76	53.00
H^+($cmolkg^{-1}$)	0.13 – 0.63	0.25	0.20	80.0
CEC ($cmolkg^{-1}$)	1.66 – 4.02	2.84	0.76	26.8
Av.P ($mgkg^{-1}$)	0.53 – 2.57	1.60	0.57	35.6
Fe2+ ($mgkg^{-1}$)	0.56 – 1.11	0.76	0.16	21.10
Al^{3+} ($cmolkg^{-1}$)	0.10 – 1.52	1.02	0.45	44.12
N%	0.01 – 0.12	0.08	0.03	37.50
OC%	0.71 – 1.18	0.92	0.18	20.00
Cu^{2+} ($mgkg^{-1}$)	2.40 – 4.70	3.48	0.87	24.90
Zn^{2+} ($mgkg^{-1}$)	1.10 – 5.20	2.64	1.29	48.90
Mn^{2+} ($mgkg^{-1}$)	8.20 – 103.00	47.71	33.89	71.00

Table 8: Range, Mean (X), Standard deviation (SD) and coefficient of variance (CV %) of some chemical properties of Ondo inland valley swamp

Variables	Range	Mean	SD	CV %
pH	3.67 – 4.69	4.23	0.29	6.90
K^+ ($Cmolkg^{-1}$)	0.14 – 0.27	0.19	0.05	26.3
Na^+ ($Cmolkg^{-1}$)	0.03 – 0.10	0.06	0.02	33.33
Ca^{2+} ($Cmolkg^{-1}$)	0.34 – 1.14	0.73	0.27	37.00
Mg^{2+} ($Cmolkg^{-1}$)	1.17 – 2.84	1.67	0.47	28.00
H^+ ($Cmolkg^{-1}$)	0.69 – 1.17	0.91	0.13	14.70
CEC ($Cmolkg^{-1}$)	2.78 – 5.49	3.56	0.86	24.00
Av.P ($mgkg^{-1}$)	0.33 – 3.12	1.60	0.75	46.98
Fe^{2+} ($mgkg^{-1}$)	1.44 – 2.97	1.90	0.47	24.70
Al^{3+} ($Cmolkg^{-1}$)	1.03 – 1.43	1.18	0.13	11.02
N%	0.04 – 1.84	0.31	0.33	185.0
OC%	0.09 – 1.47	0.77	0.40	50.50
Cu^{2+} ($mgkg^{-1}$)	0.85 – 2.80	2.01	0.53	27.00
Zn^{2+} ($mgkg^{-1}$)	1.30 – 3.40	2.26	0.63	27.80
Mn^{2+} ($mgkg^{-1}$)	1.50 – 58.00	19.43	16.93	87.15

Conclusion

The physico-chemical properties of Ogbomoso and Ondo inland valley soils were partly influenced by effect of high rainfall regime of the areas. This results in leaching and run off processes that transport nutrient materials away from the soil. The soils were weakly developed and are of young parent materials. Fe, Mn, Zn, and Cu from both sample sites and profiles, were deficient in the area. The distribution of these micronutrients in the study areas suggests that supplementary application of Fe will be required for sustainable crop production most especially, production of rice.

Based on the findings, the low soil fertility was attributed to low soil organic matter, nitrogen, phosphorous, exchangeable basic cations and low contents of the soil micronutrients. It was observed that, continual cropping without concurrent use of manure and inorganic fertilizers had contributed to soils nutrient deficiencies and reduced soil fertility, leading to low crop yields on the farms. For optimum productivity on these soils, an integrated nutrient management system should be adopted which will embrace use of organic and inorganic nutrient sources in a sustainable way.

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